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**Childcare Attendance and Obesity Risk**

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**Abbreviations:** IV, Instrumental Variable, BMI, Body Mass Index; ECLS-B, Early Childhood Longitudinal Study Birth Cohort; NCES, National Center for Education and Statistics; OLS, Ordinary Least Squares; SES, Socio-Economic Status; 2SLS, two-stage least squares; US, United States

**What's Known on This Subject:** Several observational studies have reported that children who receive non-parental childcare are at increased risk of obesity, but this may be due to unmeasured confounding or selection into childcare, and not to the effect of childcare attendance on obesity risk.

**What This Study Adds:** Using two quasi-experimental approaches that attempted to minimize bias inherent in observational studies did not provide strong evidence for a significant relationship between non-parental childcare attendance and obesity.

## Contributors' Statement Page

**Contributors' Statement:**
Dr Isong conceptualized and designed the study, conducted the analyses, drafted the initial manuscript, and made final revisions based on critical feedback received from Drs Kawachi, Richmond and Avendaño. She approved the final manuscript as submitted.

Drs Kawachi, Richmond and Avendaño conceptualized the study in collaboration with Dr Isong, reviewed the results, reviewed and provided critical feedback for the manuscript, and approved the final manuscript as submitted.

**Abstract**

**Background and Objectives:** Several observational studies have reported that children who receive non-parental childcare are at increased risk of obesity. However, this may be due to unmeasured confounding or selection into different types of childcare. It is not well established whether this association reflects a causal effect of childcare attendance on obesity risk. We examined the effect of attending childcare on children's BMI z-scores, using nationally representative data of ~10,700 children followed from age 9 months through kindergarten-entry.

**Methods:** We first employed OLS regression to evaluate longitudinal associations between childcare attendance at 24months and BMI z-scores at kindergarten-entry, controlling for child, family and neighborhood characteristics. Because type of childcare is associated with unobserved confounding factors, we repeated the analysis using two quasi-experimental approaches: 1) individual fixed-effect models, which control for all observed and unobserved time-invariant confounders; and 2) instrumental variable (IV) analysis.

**Results**: At 24 months, 48.7% of children were in non-parental childcare, and 35.1% of children were overweight/obese at kindergarten-entry. In OLS models, compared to children in parental care, children in non-parental childcare at 24 months had higher BMI z-scores at kindergarten-entry (0.08 (SE 0.03) p=0.01). By contrast, fixed-effects and IV models revealed no significant effect of childcare on BMI z-score (fixed-effects model: $\beta$=0.02 (SE 0.02) p=0.62); (IV model: $\beta$=1.12 (SE 0.76) p=0.14).

**Conclusions**: We found no consistent associations between non-parental childcare and obesity. Previously reported significant associations may be confounded by unobserved family circumstances resulting in selection into different types of childcare.

## Introduction

Childhood obesity remains a significant public health challenge in the United States, with about 22.8% of children aged 2-5 years, being classified as overweight or obese (BMI $\geq 85^{th}$ percentile) in 2011-2012.[1] Public health efforts have been directed towards childhood obesity prevention, with a recent emphasis on the early childhood period.

In 2011, approximately 60% of US children < 5 years were in some kind of regular childcare.[2] Given the significant amount of time that preschool aged children spend in non-parental childcare, researchers have hypothesized that childcare attendance may be another contributor to childhood obesity. Several studies have evaluated whether there is an association between childcare attendance and children's weight status.[3-8] Most of these studies reported an increased risk of obesity among children in non-parental childcare, compared to those cared for by their parents.[3-8] However, a major challenge is the fact that children in non-parental childcare and those in parental care may differ across many unmeasured variables not accounted for in existing studies. If the decision to place a child in non-parental childcare is correlated with unmeasured characteristics that are also associated with the child's weight status (e.g. degree of parental concern, vigilance over the child's health, or dietary choices), conventional multivariable modeling approaches may yield biased estimates.

Given recent increased focus on childcare programs as a critical component of obesity prevention efforts, a better understanding of the association between childcare and obesity is essential. Ideally, a randomized controlled trial would help resolve this research question, but true experiments are expensive, time consuming, and difficult to launch. In the absence of experimental evidence, quasi-experimental analytical approaches can be useful to shed light on

the extent to which childcare attendance may be linked to obesity. The goal of this study was to examine the association of attending childcare with children's BMI z-scores, using both conventional methods as well as quasi-experimental techniques to account for selection bias and unmeasured confounding. Using data from a unique birth cohort study of ~10,700 children in the US followed from age 9-months through kindergarten entry, we compare findings from conventional multivariable OLS modeling approaches to findings based on two quasi-experimental approaches designed to minimize the effect of selection bias and unmeasured confounding, viz. fixed effects analysis and instrumental variable (IV) estimation. To our knowledge, this is the first study to use quasi-experimental techniques to examine the links between childcare attendance and children's weight status, a question with important policy implications for childhood obesity prevention.

**Methods**

We used data from the Early Childhood Longitudinal Study Birth Cohort (ECLS-B), a study conducted by the National Center for Education and Statistics (NCES).[9] ECLS-B includes a nationally representative sample of about 10,700 US children from diverse socio-economic and racial/ethnic backgrounds, born in 2001 and followed over ~6 years. Children's physical, social, and emotional development characteristics were measured in multiple settings. Data were also collected from parents/guardians, teachers, childcare and early education providers. Five waves of data were collected: Wave 1 (9 months, 2001-02) Wave 2 (2 years, 2003-04), Wave 3 (preschool, 2005-06), Wave 4 (kindergarten, 2006-07) and Wave 5 (a sample of children who entered kindergarten in 2007-2008). Twins, low birth-weight, American-Indian and Alaska

Native, Chinese, other Asian and Pacific-Islander children were oversampled. Data from waves 1-4 were used for this study.

*Outcome variable*

The outcome variable for this study was children's BMI-z score at waves 2-4. Children's length or height and weight were measured at each wave of ECLS-B data collection. A measure mat, stadiometer, and a digital bathroom scale were used to obtain children's length, height, and weight measurements, respectively. For all children ≥24months, we used the Centers for Disease Control and Prevention (CDC) sex-specific growth charts to calculate BMI percentile ranking and z-scores.[10] For longitudinal analyses, we used repeated continuous measures of the BMI z-scores.

*Exposure variable*

Childcare Arrangement:

Parents were asked questions about different types of childcare (other than occasional babysitting) the child received on a regular basis, regardless of whether there was a charge or fee. Using parent responses, ECLS-B developed a composite variable that indicated the childcare arrangement for each child, based on where the child spent the most hours per week. We dichotomized this variable as parental care (reference category) vs. non-parental childcare.

*Other covariates*

Additional model covariates included the child's age, gender, race/ethnicity; maternal age and maternal weight (in kg), family socio-economic status (SES), household structure (two-parent vs. single-parent)), and neighborhood-level (neighborhood safety) characteristics. We selected these variables as confounders because previous studies suggest they are associated with both type of childcare attendance and BMI.[11-20] The SES variable was an ECLS-B derived composite variable that was categorized into quintiles. It comprised information on the mother and father's educational attainment, occupational status, and household income. We used the ECLS-B SES composite variable from wave 1 (baseline) of data collection. Neighborhood safety was based on a question to assess parent's perception of their neighborhood safety: *"Do you consider your neighborhood very safe from crime, fairly safe, fairly unsafe, or very unsafe."* Possible responses included very safe, fairly safe, very unsafe and fairly unsafe. If parents' response was very unsafe and fairly unsafe, the child's neighborhood safety was categorized as unsafe (vs. safe).

*Statistical Analysis*

Information on several demographics was assessed using wave 1 data. However, the outcome variable for this study was children's BMI-z score at waves 2-4 only. We examined weight and height trajectories over time, excluding children with implausible values (n=100), who were born with low or very low birth-weight (birth-weight <2500 g) (n=3000), had height and weight values missing at every wave (n=150) or extreme BMI values (z-score >3 SD or ≤-3SD) (n=400), with a final overall sample size of ~7200. We first conducted descriptive analyses, and then employed standard multivariable OLS regression to evaluate longitudinal associations between childcare attendance at 24months and BMI z-scores at kindergarten entry, adjusting for

additional covariates. To further examine the role of selection and unmeasured confounding, we used two quasi-experimental techniques to improve causal inference using non-experimental data, namely individual fixed effect and instrumental variable (IV) models. I*ndividual fixed effect* models, used to analyze longitudinal data with repeated measures, attempts to adjust for both observed and unobserved time-invariant confounders.[21] In this within-subject design, each individual is used as his or her own control, and average differences are used to estimate the treatment effect.[21] This approach was feasible in our study because changes in the type of childcare were fairly common among children in our sample, i.e., ~56% of children transitioned from parental to childcare (or vice versa) at some point during the follow-up. Overall, only 5.7% of children were only ever in parental care, indicating that most of the variation was within individuals over time. We estimated the "childcare effect" for each child by comparing each child's BMI z-score in parental care vs. non-parental childcare, and then averaged differences across the population, to obtain the average treatment effect. The fixed effects models also included the following time-varying covariates: employment status, household structure, change in place of residence, and socio-economic status for each wave. To isolate effects of unidirectional transitions from parental care to non-parental childcare, we carried out supplementary analyses on a subset of children who had only moved from parental care to non-parental childcare across waves. Last, to evaluate a potential delayed effect of childcare on future BMI z-scores, we also estimated models that examined the lagged effects of childcare transitions on BMI z-scores.

*Instrumental variable (IV) analysis* - a known econometric technique, examined whether 'semi-random' variation in childcare attendance caused by a third variable believed to be unrelated to BMI might lead to increased BMI z-scores. We used two-stage least squares (2SLS)

regression to estimate effects. Three assumptions must be met for IV analysis to yield unbiased estimates. The instrument must: 1) affect the exposure; 2) be unrelated to the outcome, except through its effect on the exposure; and 3) be independent of the unmeasured confounding.[22] The main challenge in IV analysis is to identify an instrument that meets all three conditions. After exploring several potential alternatives, we chose as instrument - the number of relatives that live close to the family, assessed by the question: "How many of your relatives live in the area?" Our rationale was that the number of relatives living in the area would make the need for non-parental childcare more or less, but it would not necessarily be directly associated with BMI other than through influencing the risk of childcare attendance. To minimize the impact of confounding variables that could invalidate the third criterion, we adjusted for a wide array of additional covariates, conditional on which we expected the instrument to be valid. We evaluated the strength of the instruments (criterion 1 above) using conventional F-statistics from the first stage in the 2SLS approach. The F statistic was 19.6, indicating the absence of a weak instrument problem.[23] We repeated the analyses including the children with delayed kindergarten entry and the results did not change. Descriptive analyses accounted for the ECLS-B complex sample design and response rates, using appropriate ECLS-B weights. We conducted regression analyses with and without sample weights,[24] and obtained qualitatively similar results. Results from unweighted analyses are presented. All analyses were performed using statistical software (SAS v9.3; SAS Institute, Inc, Cary, NC). The study was approved by NCES and Harvard School of Public Health IRB. Per ECLS-B data reporting requirements, all figures are rounded to the nearest 50.

**Results**

Table 1 shows socio-demographic characteristics of the sample, by childcare status. Overall, about half of the children were white (54.6%), males (51.7%) and had parents with ≤ High School/GED education (46%). At 24 months, 48.7% of children were in non-parental childcare and 35.1% of children were overweight/obese at kindergarten entry. African-American children comprised 11.1% of children in parental care, and 20.6% of children in non-parental childcare. A greater proportion of Hispanic children was in parental childcare – they comprised 26.6% of children in parental care, and 19.4% of children in non-parental childcare. Children with mothers with ≤High-School diploma/GED comprised 52.1% of children in parental care and 39.7% of children in non-parental childcare. The average BMI z-score of children in non-parental childcare was significantly higher than those in parental care at each wave of data collection ($p < 0.05$). (Figure 1)

Results from multivariable linear regression models are summarized in Table 2, alongside results from fixed effect and IV models. In regular OLS models, children in non-parental childcare at 24 months had higher BMI z-scores at kindergarten entry than children in parental care (β=0.08 (SE 0.03) p=0.01; n=4700). This represents about 12% of the mean BMI z-score. However, results from fixed effects regression models (column 2), which controlled for time-varying and time-invariant confounding, indicated no significant relationship between non-parental childcare and BMI z-score (β=0.02 (SE 0.02) p=0.41; n=4700). Sensitivity analyses to assess the impact of unidirectional changes in childcare arrangements across waves, as well as the lagged childcare variable yielded very similar results (model using subset of children: β=0.05 (SE 0.06) p=0.39; n=2400); (model using lagged childcare variable: β=0.01 (SE 0.02) p=0.66; n=4700).

Results from the first stage of the IV estimation are shown in the third column of Table 2 and suggest that our main instrument, the number of family members living in the area significantly increased the likelihood that children received non-parental childcare (β=0.04 (SE 0.01), F-statistic =19.6). (The type of non-parental childcare received was relative care.) Although estimates were imprecise and had large standard errors, results from the second stage of the IV (column 4) suggest that receiving non-parental childcare was not significantly associated with BMI z-score at kindergarten entry (β=1.12 (SE 0.76) p=0.14; n=4700). We assessed the impact of SES quintiles at later waves, and results remained consistent. Because children in non-parental childcare comprised 3 different childcare categories (relative care, non-relative care, and center-based childcare), we conducted sensitivity IV analyses using pairwise comparisons between parental childcare and each type of non-parental childcare. None of these models yielded significant results.

**Discussion**

Non-parental childcare in early childhood has been associated with obesity. [3-8] In particular, children in relative, friend or home-based non-parental childcare have been previously reported to gain more weight, compared to children in parental care.[5,25] Our study, using two quasi-experimental approaches that attempt to minimize bias inherent in observational studies, does not provide strong evidence for a relationship between non-parental childcare and obesity.

Conventional analytical approaches, while often controlling for a rich set of measured confounders, may not fully account for unmeasured or unobservable differences between children in different childcare arrangements. For example, parents who choose to take care of their children at home may also be more likely to cook healthier diets or emphasize healthy

habits than parents that send their children to child care. This would imply that it is not childcare per se which increases the risk of obesity but other unmeasured behaviors that tend to cluster among parents who stay home with their children, and which are correlated with child weight.

It is noteworthy, that not all studies evaluating the association between childcare and children's weight status have yielded a positive association. Some studies reported no significant association,[26-29] while one study found an inverse association among children with limited center-based childcare attendance in preschool years.[26] Inconsistencies in results may be due to differences in sample characteristics, analytical approach, or confounders controlled for in the studies. Some studies have also reported effect modification in the relationship by some familial characteristics. A UK based study found that the positive childcare/obesity relationship was limited to children of parents who had more socioeconomically advantaged backgrounds.[6]

Despite many strengths in our data and approach, several limitations in this study should be considered. Children in our sample were only followed through kindergarten entry; if the impact of childcare on weight status only manifests after this age, we would not have detected any effects using our data. However, a study that assessed the long term impact of childcare on weight status in female adults did not find any significant associations.[29] Fixed effects models control for time-invariant confounders but not time-varying confounders, some of which may be correlated with changes in BMI. We tried to minimize this bias by including as many time-varying confounders as possible in the model, but could still have omitted some important variables. Additional limitations of fixed effects analysis include the possibility that lag times were mis-specified, potential simultaneity, and sample size limitations because data on kids whose childcare arrangements did not change were not used. Finally, the IV technique could be biased when there are sample size limitations.[30] As such, results from the IV analysis should be

interpreted with caution, given the large standard errors and the possibility that our analysis may have been under-powered. We did not evaluate the impact of timing of non-parental childcare, but pairwise comparisons between parental childcare and each type of non-parental childcare yielded qualitatively similar results. The IV analysis relies on strong assumptions that cannot be fully verified empirically. For example, the presence of direct effects of the instrument on BMI can never be fully tested empirically in an instrumental variable analysis, and our results therefore rely on the assumption of no direct effects. We repeated our analyses using three strong instruments, and results remained consistent. Overall, although quasi-experimental techniques are not without limitations, our results do provide a richer picture that casts doubt on the hypothesis that non-parental childcare is associated with higher risk of obesity.

**Conclusions**

We found no consistent associations between non-parental childcare and obesity. Earlier reported associations may be confounded by unobserved family circumstances resulting in selection into different types of childcare arrangement. Results of previous studies have led to calls to revamp childcare policies and promote reorganization of childcare settings in order to address obesity risk factors among children in non-parental childcare. Because an increasing proportion of US children spend a significant amount of time in non-parental care, efforts to enhance the quality of care provided in these settings are reasonable approaches. However, there is a need for a better understanding of factors that inform parents' childcare decisions in order to fully tease apart the association between childcare attendance and children's weight in the short or long term. Future studies, particularly rigorous randomized controlled trials may be required

to fully address this complex question. Findings from such studies could inform how best to allocate limited obesity prevention resources.

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As is required by the terms of the National Center for Education and Statistics (NCES) restricted-use data license, this manuscript was submitted to the NCES Data Security Office for disclosure review and clearance prior to submission.

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TABLE 1: Sociodemographic characteristics of the sample population, overall and by childcare arrangement status: Early Childhood Longitudinal Survey, Birth Cohort

| Characteristic | Overall (n~7200[†]) | Parental care (%) | Non-Parental Childcare (%) |
|---|---|---|---|
| Prevalence | | 51.3 | 48.7 |
| Male | 51.7 | 49.6 | 53.1 |
| Child race | | | |
| African-American | 15.7 | 11.1 | 20.6 |
| Hispanic | 23.1 | 26.6 | 19.4 |
| Asian | 3.4 | 3.7 | 3.1 |
| Other | 3.2 | 3.1 | 3.1 |
| White | 54.6 | 55.4 | 53.9 |
| Household Income | | | |
| ≤$25,000 | 33.9 | 37.0 | 30.3 |
| $25,001-50,000 | 29.3 | 31.9 | 27.4 |
| >$50,000 | 36.8 | 31.1 | 42.3 |
| Parent Education | | | |
| ≤High School/GED | 46.0 | 52.1 | 39.7 |
| Vocational school/Some College | 29.3 | 27.3 | 31 |
| ≥Some College | 24.8 | 20.6 | 29.3 |
| Two parent household | 80.6 | 85.6 | 75.3 |
| Unsafe Neighborhood | 8.1 | 9.4 | 7.2 |
| Overweight/Obesity Prevalence (%) | | | |
| 2-yr (2003-04) | 17.1 | 14.9 | 19.4 |
| Preschool (2005–06) | 34.4 | 33.1 | 35.7 |
| Kindergarten (2006) | 35.1 | 33.2 | 37.1 |

[†] Unweighted sample size rounded to the nearest 50, in compliance with NCES ECLS-B data reporting requirements.

Figure 1: Mean BMI Z-Score Trajectories by Childcare Arrangement: Early Childhood Longitudinal Survey, Birth Cohort

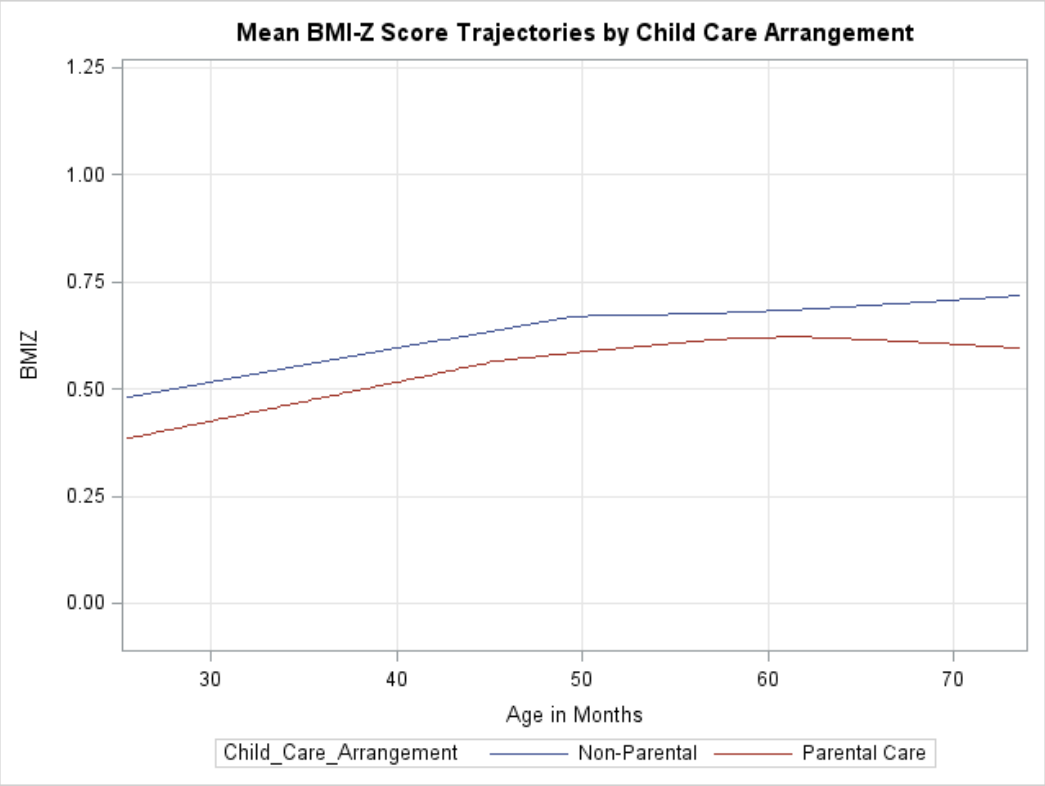

Table 2: OLS, Fixed Effects and Instrumental Variable Multivariable models examining the association of childcare attendance and BMI z-scores: Early Childhood Longitudinal Survey, Birth Cohort

| | **OLS multivariable regression analysis**** | **Fixed effects model analysis**§** | **First Stage Instrumental Variable analysis** | **Instrumental variable analysis**** |
|---|---|---|---|---|
| | β (SE) | β (SE) | β (SE) | β (SE) |
| Childcare | 0.08 (0.03)* | 0.02 (0.02) | | 1.12 (0.76) |
| Close Relative (1st stage IV analysis)† | | | 0.04 (0.01) | |
| Age (in months) | 0.01 (0.01) | 0.003 (0.003) | 0.02 (0.01) | -0.01 (0.02) |
| Male | 0.07 (0.03)* | 0.09 (0.03) | 0.01 (0.01) | 0.05 (0.03) |
| Socioeconomic status | -.06 (0.01) | -0.07 (0.02)* | 0.06 (0.01) | -0.13 (0.05)* |
| Race | | | | |
| African-American | 0.12 (0.05)* | 0.05 (0.05) | 0.14 (0.03) | -0.02 (0.12) |
| Hispanic | 0.19 (0.04)* | 0.12(0.04)* | 0.03 (0.02) | 0.16 (0.05)* |
| Asian | -0.18 (0.05)* | -0.15 (0.04)* | -0.02 (0.02) | -0.15 (0.06)* |
| Other | 0.19 (0.05)* | 0.14 (0.05)* | 0.03 (0.02) | 0.16 (0.06)* |
| Maternal age (in years) | 0.00 (0.003) | 0.000 (0.003) | -0.001 (0.001) | 0.001 (0.003) |
| Unsafe Neighborhood | 0.04 (0.06) | -0.02 (0.05) | -0.06 (0.03)* | 0.10 (0.08) |
| Two parent household | -0.04 (0.04) | -0.01 (0.05) | -0.17 (0.02)* | 0.13 (0.14) |
| Maternal weight (in kg) | 0.002 (0.00)* | 0.002 (0.00) | 0.00 (0.00) | 0.002 (0.001)* |

** Confounders in all models included child age, race/ethnicity, gender, maternal age, maternal weight (in kg), household structure, family socioeconomic status and neighborhood safety.
§Model also controlled for other time varying covariates – employment status, change in residence, household structure and socio-economic status for each wave of data
*p-value <.05
† Close relative variable only included in Instrumental Variable Analysis